SHORT REPORT

A Comparison of Digital Retinal Images and 35 mm Colour Transparencies in Detecting and Grading Diabetic Retinopathy

L.D. George[1]*, M. Halliwell[2], R. Hill[2], S.J. Aldington[3], J. Lusty[4], F. Dunstan[5], D.R. Owens[1]

[1]*Diabetes Research Unit, Llandough Hospital and University of Wales College of Medicine, Cardiff*
[2]*Department of Ophthalmology, University Hospital of Wales, Cardiff*
[3]*Retinopathy Grading Centre, Royal Postgraduate Medical School, London*
[4]*Department of Media Resources, University Hospital of Wales, Cardiff*
[5]*Department of Medical Statistics, University of Wales College of Medicine, Cardiff*

We compared digital retinal images and 35 mm colour transparencies taken with the Canon CR5 retinal camera for the detection and grading of diabetic retinopathy in a clinical setting, in a randomized, blinded study of diabetic patients with a spectrum of severity of diabetic retinopathy. Forty patients were photographed, giving a total of 75 eyes including non-diabetic eyes as controls. Images were graded according to the validated European guidelines. There was exact agreement between grades obtained from both the 2 field 45° 35 mm colour transparencies and digital images in 93.3 % (70/75) of eyes, with Cohen's Kappa statistic for the comparison being 0.92. Overall, when grading from the digital images 5.3 % (4/75) eyes were undergraded with three cases of sight threatening diabetic retinopathy (STDR) graded as non-sight threatening (NSTDR) (3/48, 6.3 %). One eye was overgraded (1/75, 1.3 %). Two of the three cases of STDR undergraded as NSTDR had small numbers of intra-retinal microvascular abnormalities (IRMA) discernible on the colour transparencies but which were not visible from the digital image. The third had multiple small cotton wool spots graded as laser photocoagulation scars from the digital images. In conclusion there is good to excellent agreement between retinopathy grades using the Canon CR5 digital retinal imaging system compared to 35 mm colour transparencies.

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Introduction

Despite the fact that treatment is known to be effective in preserving sight,[1–4] diabetic retinopathy (DR) remains the most common cause of new blindness in the working population in England and Wales.[5] The Saint Vincent declaration[6] objectives include the reduction of new blindness due to DR by one-third. It is essential to diagnose DR early ensuring prompt intervention and treatment. While there is agreement about the importance of screening for DR there remains debate as to which screening modality is preferable for detecting sight threatening diabetic retinopathy (STDR). Retinal photography is superior to ophthalmoscopy, improving sensitivity from 65 % to 89 %[7] and the combined modalities of ophthalmoscopy and retinal photography will offer improved sensitivity and specificity compared to ophthalmoscopy alone.[8] Polaroid photography offers instant availability of the retinal image which may be used to direct ophthalmoscopy and educate patients and carers. However Polaroid prints may fade with time and are more expensive than 35 mm colour transparencies. Dedicated digital retinal cameras are capable of immediately displaying a retinal image onto a high resolution computer monitor. We compared digital retinal images and 35 mm colour transparencies taken as two overlapping, non-stereoscopic 45° retinal fields using the Canon CR5 45NM digital retinal camera system for detecting and grading DR.

Research Design and Methods

Ethical approval was obtained from the local ethics committee. All patients gave written informed consent.

Correspondence to: Dr Lindsay George, Diabetes Research Unit, Academic Centre, Llandough Hospital, Penlan Road, Penarth, Cardiff, South Glamorgan CF64 2XX, UK

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Seventy-five eyes representing a known spectrum of diabetic retinopathy as graded from 7 field stereoscopic 30° retinal photographs ($n = 70$) including some normal eyes ($n = 5$) were recruited from diabetes and ophthalmology clinics and photographed. Patients had their pupils dilated with 1 % tropicamide and 2.5 % phenylephrine repeated if required to achieve a minimum pupil diameter of 6 mm. Patients were then photographed, the digital images taken first, allowing a short break between sessions to reduce discomfort.

Digital Images

Two 45° non-stereoscopic images, one macula centred and one of the nasal field were taken of each eye by an experienced medical photographer. The Canon CR5 45NM non-mydriatic retinal camera (distributed by Clement Clarke International Ltd) fitted with the Canon CR-TA video adaptor, Sony DXC 950P three chip video camera (resolution 785 X 576 pixels) and a Nubus video frame capture board was used.[9] It is run on a Macintosh Power Computing, Power Curve 601/120 computer with 40 Mb of RAM using RIS-Lite CCI v 3.5 imaging software (Frost Medical Software) at a screen resolution of 1024×768 pixels in 24 bit colour (16.7 million colours) on a 42.5 cm high resolution Trinitron monitor.

45°, 35 mm Transparencies

Two 45°, non-stereoscopic images were taken of each eye by the study photographer using the same Canon CR5 45NM retinal camera equipped with a Canon R-E 35 mm camera back and Kodak Ektachrome EB 100 colour transparency film. The film was bought in bulk, stored in a refrigerator as recommended by the manufacturer and processed within 24 hours of photography.

Grading of Retinal Images

The 45° digital images and transparencies were anonymized, identifiable only by a unique patient number and graded in random order, twice each as a quality control according to two different randomization schedules by a research physician (LDG) with two years' grading experience. Where the two grades differed, an independent adjudicator (DRO) performed a final overall grading. Eyes were graded according to the WCDRS protocol (Table 1) in sessions of 15 eyes each. Transparencies were graded on a Slidex H-1 projector (Slidex Corp., Tokyo, Japan), which projects an 11× magnified image onto a screen, showing the entire 45°. The magnification of the transparencies was identical to that produced by the digital system. Digital images were graded with the hardware and software described above. Viewing conditions and monitor settings (contrast to maximum, brightness to mid position) were standardized. The digital images were enhanced at the discretion of the grader to improve image quality by software optimization of contrast, brightness and the application of sharpen filters to improve resolution. A digital zoom facility was used as required.

Results

2 Field, 45° Digital Images versus Two Field, 45° Colour Transparencies

There was exact agreement between the two quality control grading sessions in 97.3 % (73/75; 95 % CI 89.8–99.5) of eyes when grading from the colour transparencies and in 96.0 % (72/75; 95 % CI 88.0–99.0) of eyes when grading from the digital images, indicating low intra-observer variation. After clarification of the grades where disagreement occurred, there was exact agreement between grades obtained from the colour transparencies and the digital images in 93.3 % (70/75; 95 % CI 84.5–97.5) of eyes (Table 2) as represented by the shaded diagonal line. The unweighted Cohen's Kappa statistic[10] for the comparison is 0.92. Numbers above the diagonal line represent relative undergrading of the digital images in comparison to the colour transparencies while numbers below the line represent overgrading.

Results are expressed in Table 3 in simplified form as sight threatening diabetic retinopathy or non-sight threatening diabetic retinopathy (NSTDR). When comparing gradings from the digital images to the colour transparencies, four eyes were undergraded (4/75, 5.3 %): three cases of which involved STDR being graded as NSTDR (3/48, 6.3 %). One eye was overgraded (1/75, 1.3 %) resulting in one case of NSTDR being graded as STDR (1/27, 3.7 %).

Two of the three cases where STDR was undergraded showed small numbers of intra-retinal microvascular abnormalities (IRMA) on the colour transparencies, which were not visible on the digital images even in hindsight. The remainder of the eye was free from other preproliferative lesions with the IRMA confined to one discrete retinal area, occupying about the same area as the optic disc. The third case of STDR undergraded showed multiple small cotton wool spots (CWS) in a retina with pan retinal laser photocoagulation scars when graded from the colour transparencies, which were graded as laser scars from the digital images. One case of STDR was undergraded but remained in the STDR category, in which remnants of new vessels elsewhere (NVE) amongst heavy pan-retinal laser photocoagulation seen on the colour transparencies were graded as areas of haemorrhage from the digital images, due to a loss of fine detail. The single case of NSTDR overgraded showed drusen on the macula on the colour transparencies which were graded as hard exudates.

Table 1. Welsh Community Diabetic Retinopathy Study: abbreviated clinical groupings

Clinical grouping	
0	No diabetic retinopathy.
1	Non-proliferative retinopathy: Non-PDR (mild). Occasional haemorrhages and/or microaneurysms and hard exudates not within one disc diameter of the macula centre. One soft exudate per eye not associated with preproliferative lesions.
2a	Non-proliferative retinopathy: Non-PDR (moderate) without macular involvement. Large circinate or plaque of hard exudates within the temporal vascular arcades, but not within one disc diameter of the macula centre (fovea).
2b	Non-proliferative retinopathy: Non-PDR (moderate) with macular involvement (maculopathy). Haemorrhages and/or hard exudates within one disc diameter of the macula centre not including microaneurysms.
3	Pre-proliferative retinopathy: PPDR. Venous irregularities (beading, reduplication, loops) and/or multiple haemorrhages and/or multiple cotton wool spots and/ or intra-retinal microvascular abnormalities.
4	Proliferative retinopathy: PDR. New vessels on the disc or elsewhere on the retina. Pre-retinal haemorrhage and/or fibrous tissue.
5	Advanced diabetic eye disease. Vitreous haemorrhage and/or fibrous tissue and/or recent retinal detachment and/or rubeosis iridis.

NOTE: Diabetic retinopathy grades 1 and 2a regarded as non-sight threatening. Diabetic retinopathy grades 2b and above are regarded as sight threatening.

Table 2. Retinopathy grades by grading method

		35 mm Colour transparencies							
	Grade	0	1	2a	2b	3	4	5	Total
Digital images	0	5							5
	1		20			2			22
	2a			1		1			2
	2b		1		16		1		18
	3					13			13
	4						10		10
	5							5	5
	Total	5	21	1	16	16	11	5	75

Table 3. Retinopathy grades by grading method

		35 mm Colour transparencies		
		NSTDR	STDR	Total
Digital images	NSTDR	26	3	29
	STDR	1	45	46
	Total	27	48	75

Discussion

We have recently shown good agreement in retinopathy grades between digitized colour 35 mm transparencies viewed on a high resolution monitor and the original images viewed as 35 mm slides.[11] Retinal photographs were digitized at a resolution of 768×512 pixels (so as to be similar to the Canon system utilized in this paper). There was exact agreement in retinopathy grades from the digitised images and the colour transparencies in 83.3 % of cases with 95 % of STDR and 100 % of NSTDR correctly identified. Our present study now shows close agreement between retinopathy grades from digital images using a dedicated digital camera when compared to the colour transparencies for 2 field, 45° retinal photography. The resolution of the system described is still relatively low at 785×576 pixels and the digital images were more difficult to grade especially where low contrast, small lesions were seen with the higher resolution colour transparencies (which is limited only by the grain size of the film). The lesions most difficult to diagnose with the digital system were intra-retinal microvascular abnormalities, some of which were not visible on the digital image. Hard exudates were generally easier to grade. The images were easier to grade after software manipulation to improve resolution of fine detail, although in one instance this resulted in

the overgrading of drusen as hard exudates due to the increased contrast of the enhanced image.

Conclusion

We conclude that there is good to excellent agreement between retinopathy grades using the Canon CR5 digital retinal imaging system compared to 35 mm colour transparencies. This system offers improved storage, archiving, and manipulation of images, as well as instant display of images.

References

1. Anonymous. Early photocoagulation for diabetic retinopathy. ETDRS report number 9. Early Treatment Diabetic Retinopathy Study Research Group. *Ophthalmology* 1991; **98**: 766–785.
2. Anonymous. Photocoagulation treatment of proliferative diabetic retinopathy. Clinical application of Diabetic Retinopathy Study (DRS) findings, DRS Report Number 8. The Diabetic Retinopathy Study Research Group. *Ophthalmology* 1981; **88**: 583–600.
3. Anonymous. Photocoagulation for proliferative diabetic retinopathy: a randomised controlled clinical trial using the xenon-arc. *Diabetologia* 1984; **26**: 109–115.
4. Anonymous. Photocoagulation for diabetic macular edema. Early Treatment Diabetic Retinopathy Study report number 1. Early Treatment Diabetic Retinopathy Study research group. *Arch Ophthalmol* 1985; **103**: 1796–1806.
5. Evans J. *Causes of Blindness and Partial Sight in England and Wales 1990–1991*. Studies on medical and population subjects. London: HMSO, 1995.
6. Anonymous. Diabetes care and research in Europe: The Saint Vincent Declaration. *Diabetic Med* 1990; **7**: 360.
7. Harding SP, Broadbent DM, Neoh C, White MC, Vora J. Sensitivity and specificity of photography and direct ophthalmoscopy in screening for sight threatening eye disease: the Liverpool diabetic eye study. *Br Med J* 1995; **311**: 1131–1135.
8. Ryder B. Screening for diabetic retinopathy (editorial). *Br Med J* 1995; **311**: 207–208.
9. Young S, George LD, Lusty J, Owens DR. A new screening tool for diabetic retinopathy: The Canon CR5 45NM retinal camera with Frost Medical Software RIS-Lite digital imaging system. *Journal of Audiovisual Media in Medicine* 1997; **20**: 11–14.
10. Cohen J. Weighted Kappa: nominal scale agreement with provision for scaled disagreement or partial credit. *Psychological Bulletin* 1968; **70**: 213–220.
11. George LD, Leverton C, Young S, Dunstan FD, Owens DR. Can digitised colour 35 mm transparencies be used to diagnose diabetic retinopathy (DR)? *Diabetic Med* 1997; **14** (Suppl. 1): S63.

